OPAL-RT

OP5000 Signal Conditioning & I/O Products
for RT-LAB Engineering Simulators

OP5511 High-current and high-voltage input conditioning module

User Manual

OPAL-RT

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Rev. E

1 INTRODUCTION

The high-current and high-voltage input conditioning module allows the conversion of 4 current and 4 voltage signals to ±10V voltage level. The current inputs are factory configurable for up to 50A continuous. The measured voltage range is configurable for up to 600 volts by jumpers.

2 DESCRIPTION

The high current and high voltage input conditioning module allows the conversion of current and voltage to +- 10 volts signals. Such modules are typically used for monitoring current and voltage on DC/AC motors.

The front panel has activity and out-of-range LEDs for each channel. For current-measurement channels, the activity LED (green) turns on when a current above 200mA is detected, while the out-of-range LED (red) turns on when the upper current limit of the selected sensor has been reached. For voltage-measurement inputs, the activity LED (green) turns on at 2V, while the out-of-range LED turns on when the upper voltage limit of the selected range has been reached.

2.1 CHASSIS LAYOUT

Figure 1: High-current and high-voltage input conditioning module (Front)

Figure 2: High-current and high-voltage input conditioning module (Back)

2.2 FEATURES

- 4 current-measurement inputs, factory configurable for up to 50 Amps continuous.
- 4 voltage-measurement inputs, jumper configurable from 50 volts to 600 volts range.
- Rugged screw terminal connections
- Compatible with Opal-RT OP5340 analog input module
- Activity and Out-of-range LEDs for each channel

2.3 BOARD SETTINGS

2.3.1 VOLTAGE RANGE

The input voltage range is configured using a jumper on the circuit board. Each channel (Ch. A to Ch. D) can have a different range.

Available Voltage Range
50 V (no jumper)
100 V
200 V
400 V
600 V (default)

Table 1: Available voltage ranges

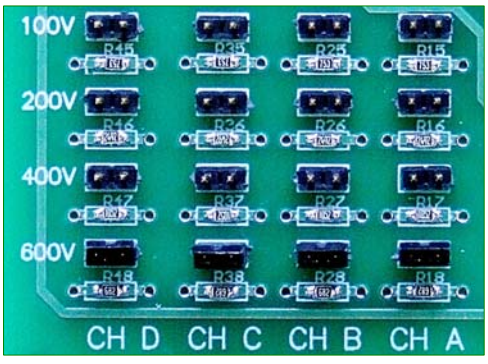


Figure 3: Jumper for voltage configuration

2.3.2 PIN ASSIGNMENTS

Figure 4 shows the front panel of the module where I/O-level signal outputs and power input are located. Connector J1 (DB25) would generally be connected to an analog-to-digital converter, such as the OP5340. The conditioning module requires a regulated ±15 volts power supply to be used. In order to reduce noise, a linear power supply is preferred. Power is connected to the J2 connector. Table 2 and Table 3 present the pin assignments for both J1 and J2 connector.
See Appendix B for mating connector part numbers.

FRONT PANEL

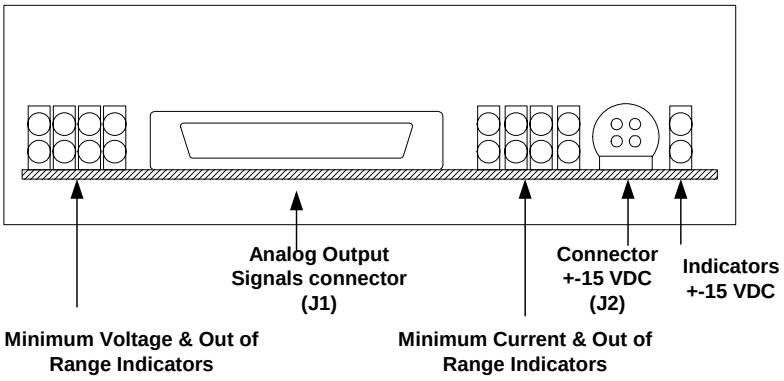


Figure 4: Front panel connectors

Pin#	Description	Pin#	Description
1	Ch A Current Sensor Output	14	GND
2	Ch B Current Sensor Output	15	GND
3	Ch C Current Sensor Output	16	GND
4	Ch D Current Sensor Output	17	GND
5	Ch A Voltage Sensor Output	18	GND
6	Ch B Voltage Sensor Output	19	GND
7	Ch C Voltage Sensor Output	20	GND
8	Ch D Voltage Sensor Output	21	GND
9	ID0	22	ID1
10	ID2	23	N/C
11	N/C	24	GND
12	- 15 volts (reference)	25	GND
13	+ 15 volts (reference)		

Table 2: J1 Connector

Pin#	Description
1	-15 volts
2	GND
3	+15 volts
4	GND

Table 3: J2 Connector

ID2	ID1	ID0	Value
0	0	0	Invalide-Default
0	0	1	4CH @ 5A
0	1	0	4CH @ 15A
0	1	1	4CH @ 25A
1	0	0	4CH @ 50A
1	0	1	Mixed channel
1 = 3.3V on pin			

Table 4 : ID configuration

The back panel includes screw terminals to connect the current (J3) and voltage (J4) inputs. To minimize connection resistance, it is highly recommended to connect only 1 wire per screw for the current input pins. If the same pin is needed to provide both current and voltage measurement, the J5 connector shall be used. See description below for details.

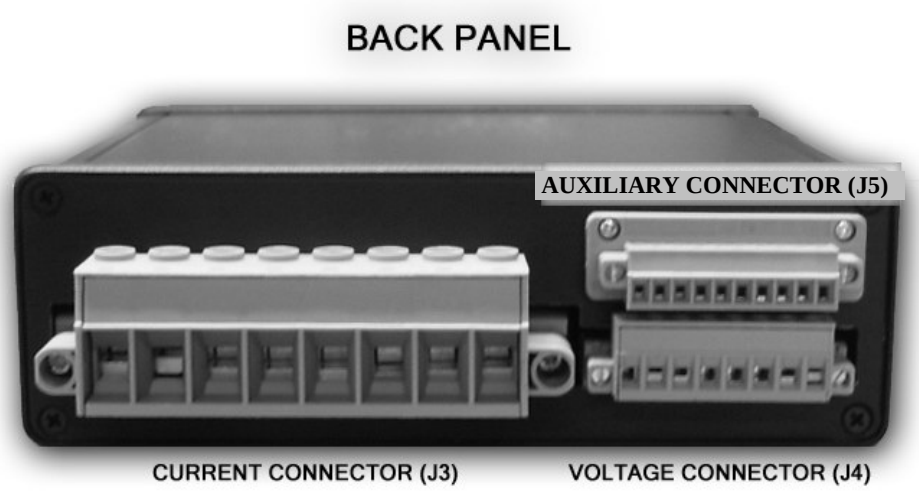
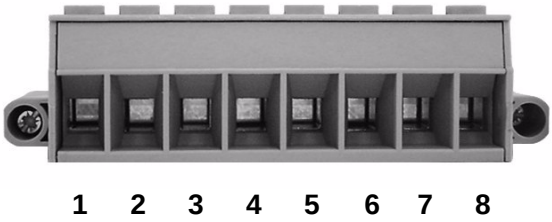


Figure 5: Back panel connectors

- Current connector (J3)



Pin #	Description
1	+ Channel A
2	- Channel A
3	+ Channel B
4	- Channel B
5	+ Channel C
6	- Channel C
7	+ Channel D
8	- Channel D

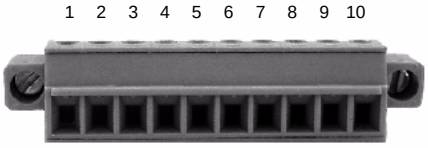
Part number: PC 16/8-STF-10,16
Nominal current: 55 A
Nominal voltage: 300 V
AWG conductor: min. 18
max. 6

- Voltage connector (J4)

Pin #	Description
1	+ Channel A
2	- Channel A
3	+ Channel B
4	- Channel B
5	+ Channel C
6	- Channel C
7	+ Channel D
8	- Channel D

Part number: BLZ 5.08/8F SN SW
Nominal current: 10 A
Nominal voltage: 300 V
AWG conductor: min. 26
max. 12

- Auxiliary connector (J5)



Pin #	Description	TP
1	Ch. A – Current Connector	J12
2	Ch. B – Current Connector	J22
3	Ch. C – Current Connector	J32
4	Ch. D – Current Connector	J42
5	Ch. A – Voltage Common	J11
6	Ch. B – Voltage Common	J21
7	Ch. C – Voltage Common	J31
8	Ch. D – Voltage Common	J41
9	GND – Internal ground	J1
10	GND – Internal ground	J2

Part number: MC 1,5/10-STF-3,81
Nominal current: 8 A
Nominal voltage: 300 V
AWG conductor: min. 28
max. 16

The first four (4) outputs, dedicated to the voltage measure, are connected to their respective channels of the current connector. Because of the unique structure of the current sensor component, the impedance between positive and negative input of each current channel is very small so the potential difference between them is almost inexistent. For this reason, only one output per channel is available on the auxiliary connector (J5).

The next four (4) outputs are connected to the common points of the voltage sensor inputs. The common point is connected to the middle of the resistor ladder between the positive and negative inputs. The voltage inputs are composed of differential amplifiers thus the common points can be connected to the internal ground of the circuitry that is available on the auxiliary connector (J5), pin 9 and 10.
See Appendix C for connection example.

3 BOARD CALIBRATION

Each high-current and high-voltage input conditioning board is calibrated after manufacturing. Two modes of calibration are available. The board can be calibrated using the reference voltages generated on the board or external source of current/voltage connected directly to the bloc terminals. The calibration of each channel is done separately. The offset and the gain are fine-tuned using multiturn potentiometers.

3.1 REFERENCE VOLTAGE SETTING.

There are two reference voltages on the board to be set: at +2.5 volts and –2.5 volts. They are used for calibration and minimum input signal (activity) and out-of-range indicators.

Figure 5: Voltage reference section

- Locate RV1 and RV2 potentiometers on the board (see APPENDIX E to locate them).
- Connect a precision voltmeter between ground and the point +2.5V on the board (see Figure 5 above)
- With RV1 potentiometer, adjust exactly the reference voltage to + 2.5 volts. More precise adjustment will be, the better results can be reach with the board.
- Do the same tuning for –2.5 volts using RV2 potentiometer.

3.2 CALIBRATING THE BOARD WITH REFERENCE VOLTAGES.

This is the first step of calibration, which permits to ensure the accurate functioning of the output section. See APPENDIX E for more details to locate the four Current Channels. See APPPENDIX F for more details to locate the four Voltage Channels.

- Locate first voltage channel on the board. The calibration section is composed of two multiturn potentiometers (RV11A, RV12A), headers with shunt (W12A, W13A) and rotary selector switch (S13A).

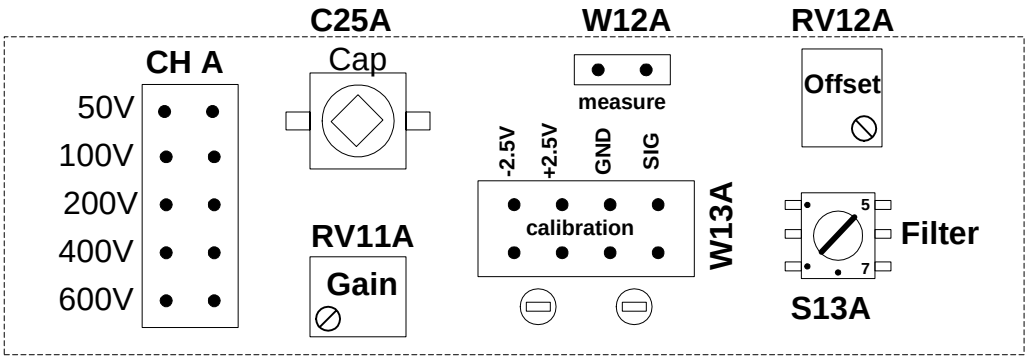
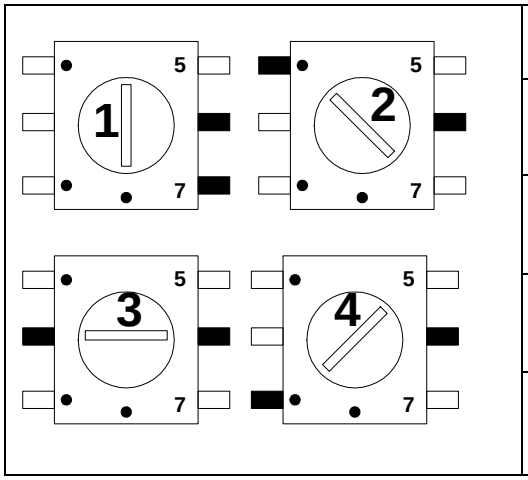


Figure 6: Calibration section

- Choose filter value by setting the appropriate rotary switch. Refer to the drawing below for existing filter values. Refer to APPENDIX D for a more detailed location.



Position	Filter
1	OFF (no filter)
2	200 HZ
3	2 KHZ
4	20 KHZ

- Connect a precision voltmeter to the first voltage channel output of the connector J1. Refer to the section 2.3.2 to know the channel output position on the connector.
- Remove the shunt from the header W12A and put it on GND position of the header W13A.
- Adjust RV12A potentiometer to read 0.000 volts on the output.
- Next, change the shunt to +2.5V position of the header.
- Adjust RV11A potentiometer to read –10.000 volts with the tolerance of +/- 0.005 volts.
- Change the shunt to –2.5V position. The voltmeter should show the same value as for the previous measure but with reverse sign if the reference voltage was properly adjusted precisely.
- After the calibration replace the shunt on the header W12A.
- Repeat these steps for the other channels. The part reference change with channels. For the voltage channels, the Gain potentiometers go from RV11A to RV11D, the Offset potentiometers go from RV12A to RV12D, the header go from W13A to W13D and the rotary switch from S13A to S13D.

  For the current channels, the Gain potentiometers go from RV51A to RV51D, the Offset potentiometers go from RV52A to RV52D, the header go from W53A to W53D and the rotary switch from S53A to S53D.

3.3 CALIBRATING THE BOARD WITH EXTERNAL SOURCES.

The first method of calibration (previous section 3.2) with the reference voltage is adequate if the lack of input section adjustment is compensated in the Simulink model. This situation can take place if the frequent changes of input range are considered. It can occur as well in the manufacturing process when the customer needs are not known.

The second method of calibration requires additional current and voltage sources, which cover whole range of the input channels. The calibration procedure is similar to the first method but the reference voltage is replaced by the external sources.

- Locate first voltage channels on the board. The calibration section is composed of two multiturn potentiometers (RV11A, RV12A), headers with shunt (W12A, W13A) and rotary selector switch (S13A).

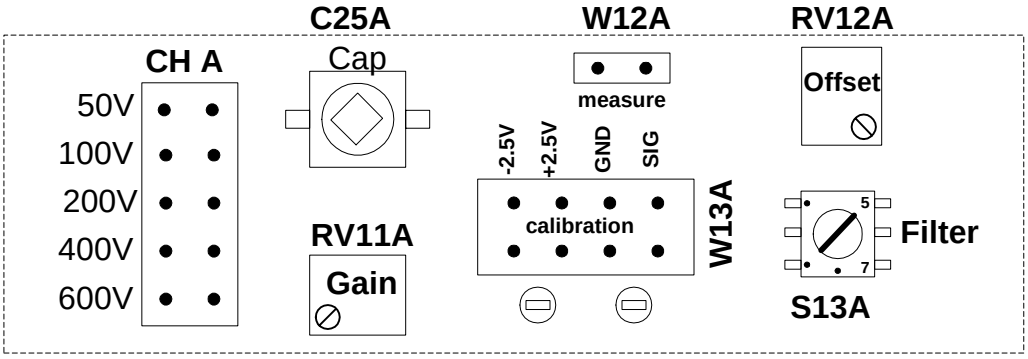
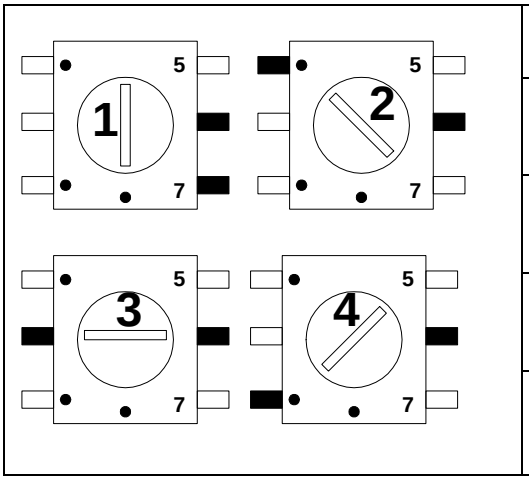


Figure 6-1: Calibration section

- Choose filter value by setting the appropriate rotary switch. Refer to the drawing below for existing filter cut-off frequency. Refer to APPENDIX D for a more detailed location.



Position	Filter
1	OFF (no filter)
2	200 HZ
3	2 KHZ
4	20 KHZ

- Choose voltage range. Section 2.3.1 describe the voltage range setting.
- Connect a precision voltmeter to the first voltage channel output of the connector J1. Refer to the section 2.3.2 to know the channel output position in the connector.
- Make sure the shunt is on the header W12A.
- Connect the voltage source to the first voltage input channel. Set it to 0 volts
- Adjust RV12A potentiometer to read 0.000 volts on the output.
- Next, change the voltage source to the range maximum value. For example, set the source to 100 volts if 100V range was chosen.
- Adjust RV11A potentiometer to read 10.000 volts with the tolerance of +/- 0.005 volts.
- Make some measure e.g. at 25%, 50%, and 75% of the range and ensure the accuracy of readings.
- Repeat these steps for the other channels. The parts references change with channels. The same procedure will be followed, as explained in the previous section for adjusting the Gain and Offset potentiometers.

3.4 OPTIMIZING THE STEP-RESPONSE.

This adjustment to optimize the step-response for each channel.

APPENDIX G shows the location of the variable capacitors for the four Current channels and for the four Voltage channels.

1.Select the proper SENSOR (5A, 15A, 25A, 50A) with the appropriate jumper for each channel or select the proper range of operation (50v, 100v, 200v, 400v, 600v) with the appropriate jumper for each channel

2. Connect a Function Generator G at the corresponding channel input.

3. Adjust the corresponding variable capacitor Cap X to get the best step response at the Outputs COx and VOx on an oscilloscope.

APPENDIX A - SPECIFICATIONS

CURRENT SENSOR CHANNEL

- Input range: factory setting (available in 5, 15, 25 and 50 amps)
- Signal output range: ± 10 volts
- Isolation: galvanic, 2.5 kV
- Bandwidth: DC to 100 kHz
- Linearity: < 0.2%
- Accuracy: < 0.5%
- Rise time: < 2 microseconds
- Power supplies: ±15 volts

VOLTAGE SENSOR CHANNEL

- Input range: jumper-selectable (50, 100, 200, 400, and 600 volts)
- Signal output range: ± 10 volts
- Common mode: greater than 200 volts after the resistive divider
- Bandwidth: DC to 100 kHz
- Linearity: < 0.2 %
- Accuracy: < 0.5 %
- Rise time: < 2 microseconds
- Power supplies: ±15 volts

CASING

- Physical dimensions: 6.3" x 6.3" x 2.0"

APPENDIX B – MATING CONNECTORS

J1 Output Signals Connector

Figure 6: J1 connector (Front view)

Part number for cable

Qty	Manufacturer	Man. Part#	Description
1	Belden	9734	12-pair, individually shielded, cable
1	NorComp	171-025-103L001	DB-25 plug, male contacts
1	NorComp	970-025-030R121	DB-25 metal back-shell

J2 Power Connector

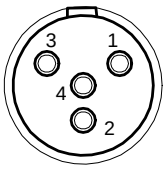


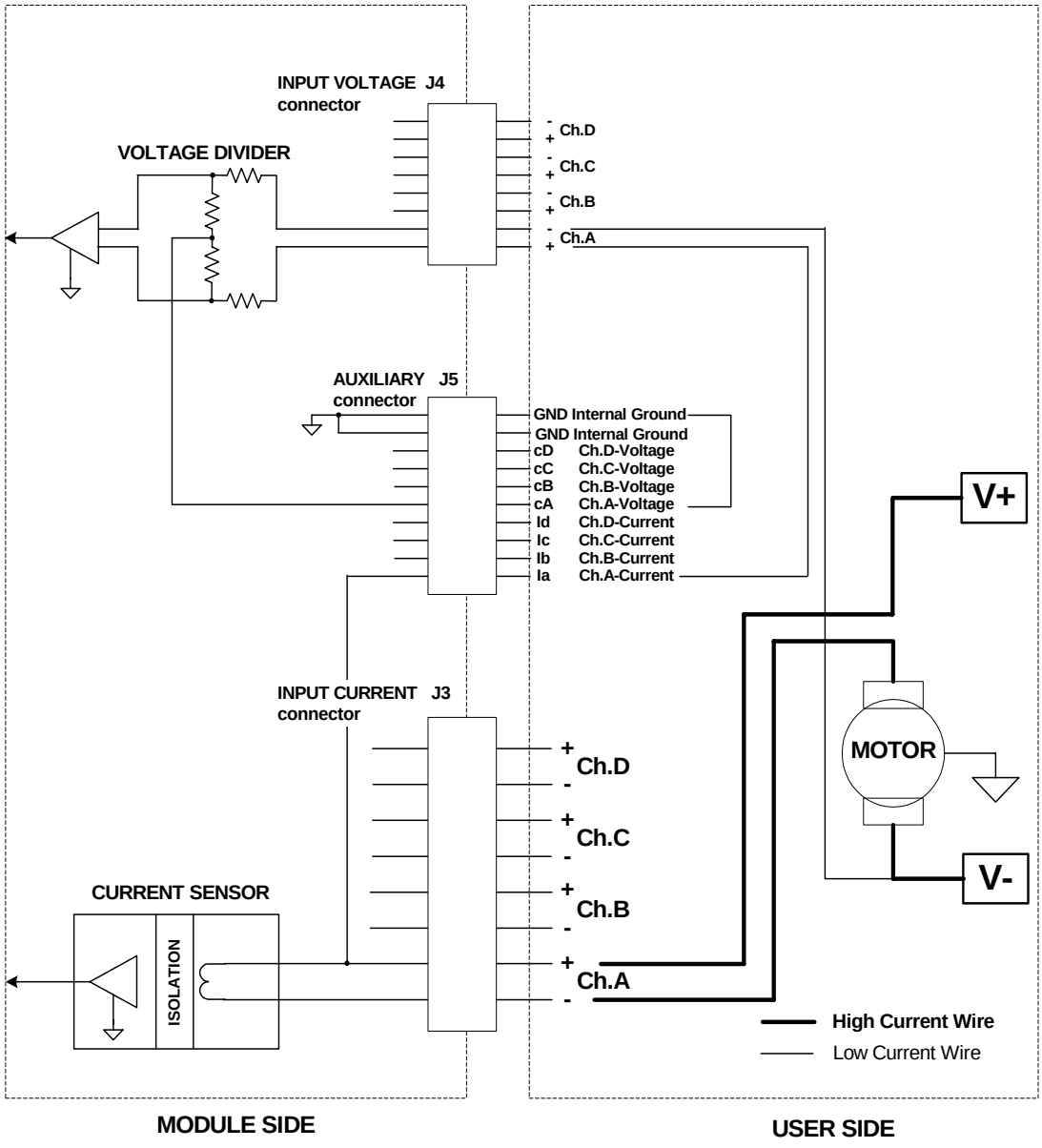
Figure 7: J2 connector (Front view)

Part number for cable

Qty	Manufacturer	Man. Part#	Description
1	Switchcraft	TA4FL	Q-G series cord plug
1	Alpha Wire	1174C	4-wire cable

APPENDIX C – CONNECTION EXAMPLE

Interconnection for measurement
Only one channel CURRENT and one channel VOLTAGE represented



To measure the Current, the cable has to pass through the Ch. A Input Current removable terminal screw connector (contact Ch. A+ and contact Ch. A.-)

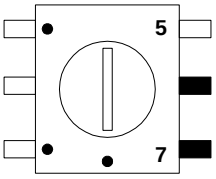
To measure the Voltage, only one wire from the motor to be connected to the Ch. A- Input Voltage removable terminal screw connector, the other part of the voltage Ch. A+ is already available on the Auxiliary connector (internal connection). Make an external wire connection between Auxiliary Ia and Voltage Ch. A+

If the reference Motor Voltage has the same ground as the Simulator, connect on the Auxiliary connector the common point Ch. A Voltage to the Simulator Ground with an external wire.

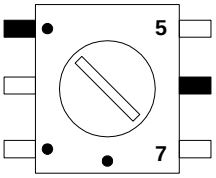
APPENDIX D. FILTER FREQUENCY SELECTION

Detail for each frequency selector, same for both Current and Voltage Channels.

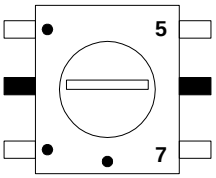
NONE



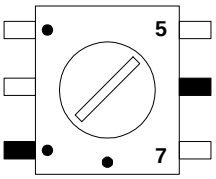
200 HZ



2 KHZ



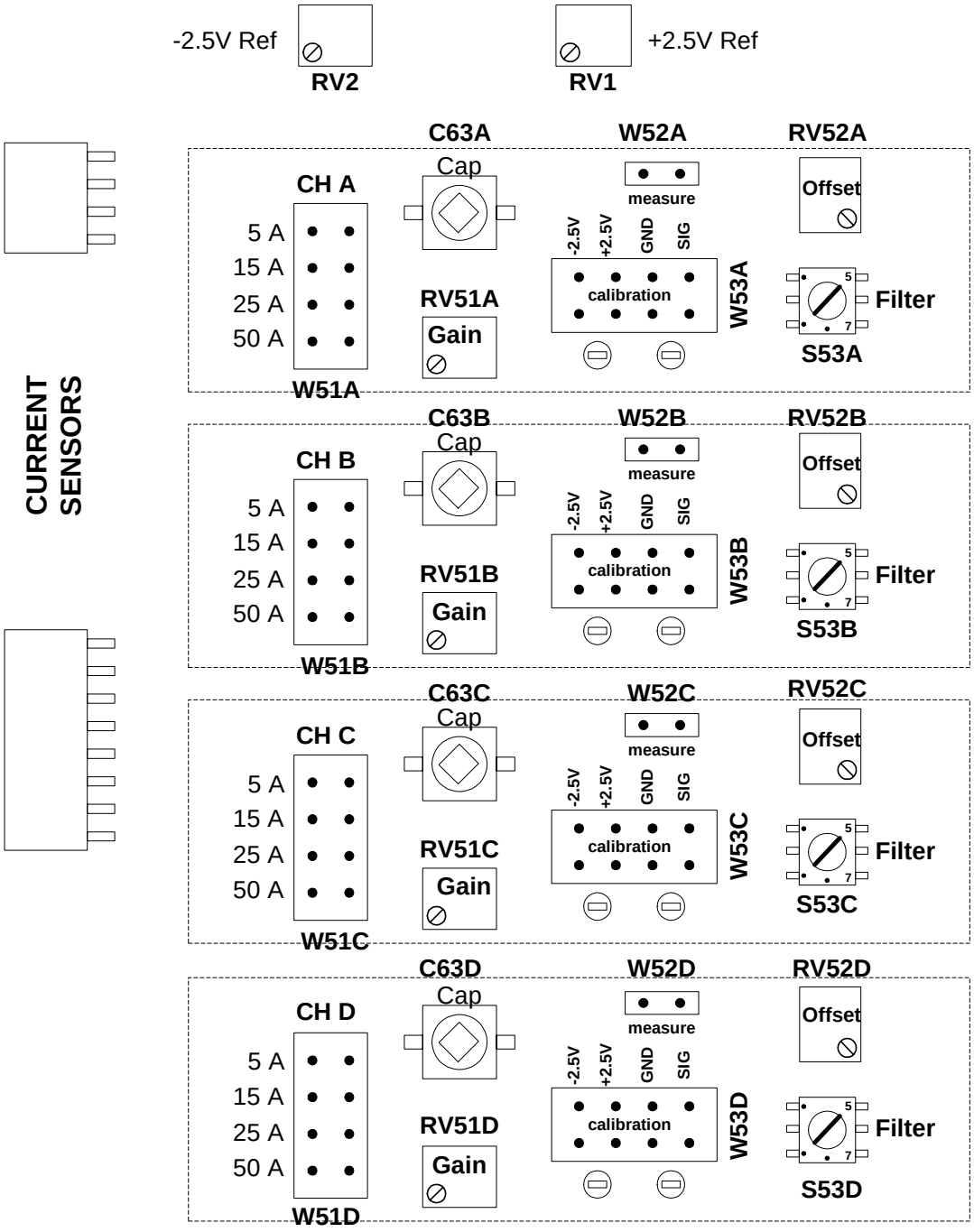
20 KHZ



VOLTAGE CHANNEL		CURRENT CHANNEL	
A	S13A	A	S53A
B	S13B	B	S53B
C	S13C	C	S53C
D	S13D	D	S53D

APPENDIX E. CURRENT SENSOR GAIN-OFFSET ADJUSTMENT

1. LAY-OUT FOR CURRENT CHANNEL POTENTIOMETERS



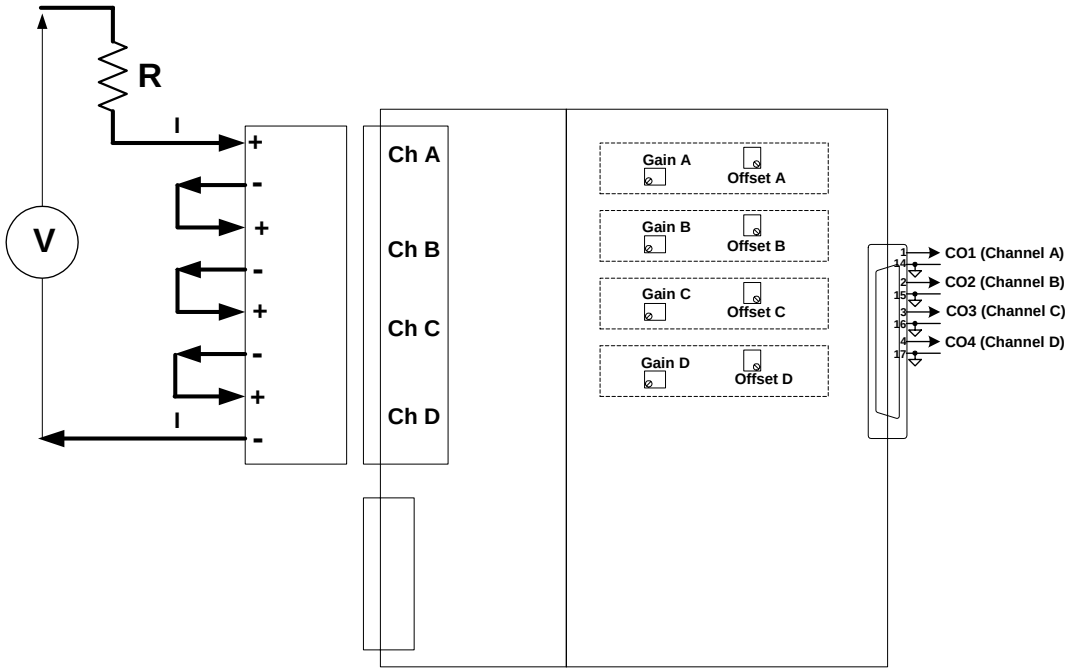
2. CALIBRATION CURRENT CHANNEL PROCEDURE:

1.Select the proper SENSOR (5A, 15A, 25A, 50A) with the appropriate jumper for each channel

2. Put current I to zero by disconnecting the inputs and cancel out the output Offset Voltage with the appropriate potentiometers Offset A, Offset B, Offset C, Offset D

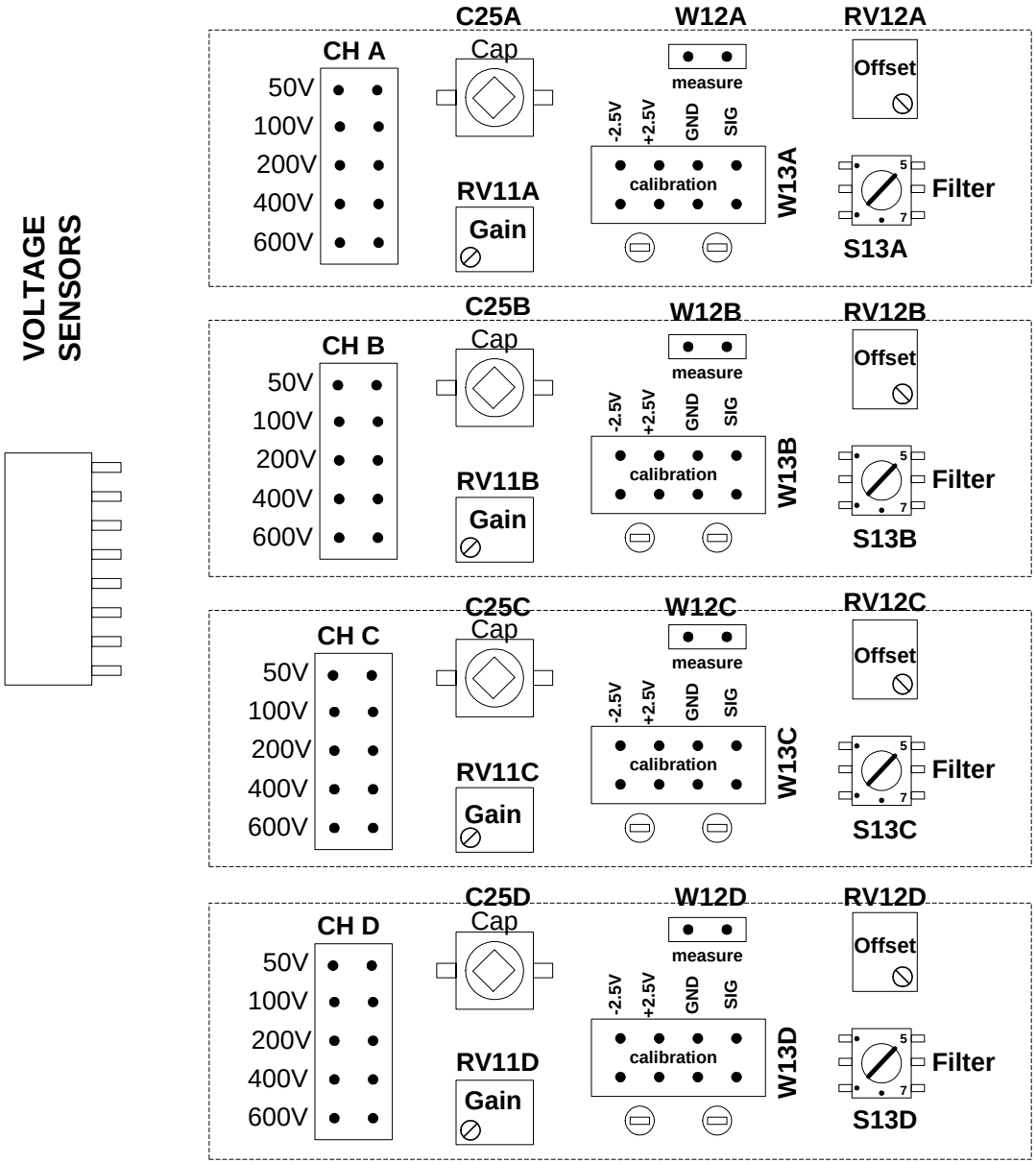
3. Put current I to a known value between in the range and adjust the Gain with the appropriate potentiometers Gain A, Gain B, Gain C, Gain D

4. If the channels don't have the same SENSOR, they must be calibrated individually at the step 3



APPENDIX F. VOLTAGE SENSORS GAIN-OFFSET ADJUSTMENT

1. LAY-OUT FOR VOLTAGE CHANNEL POTENTIOMETERS.



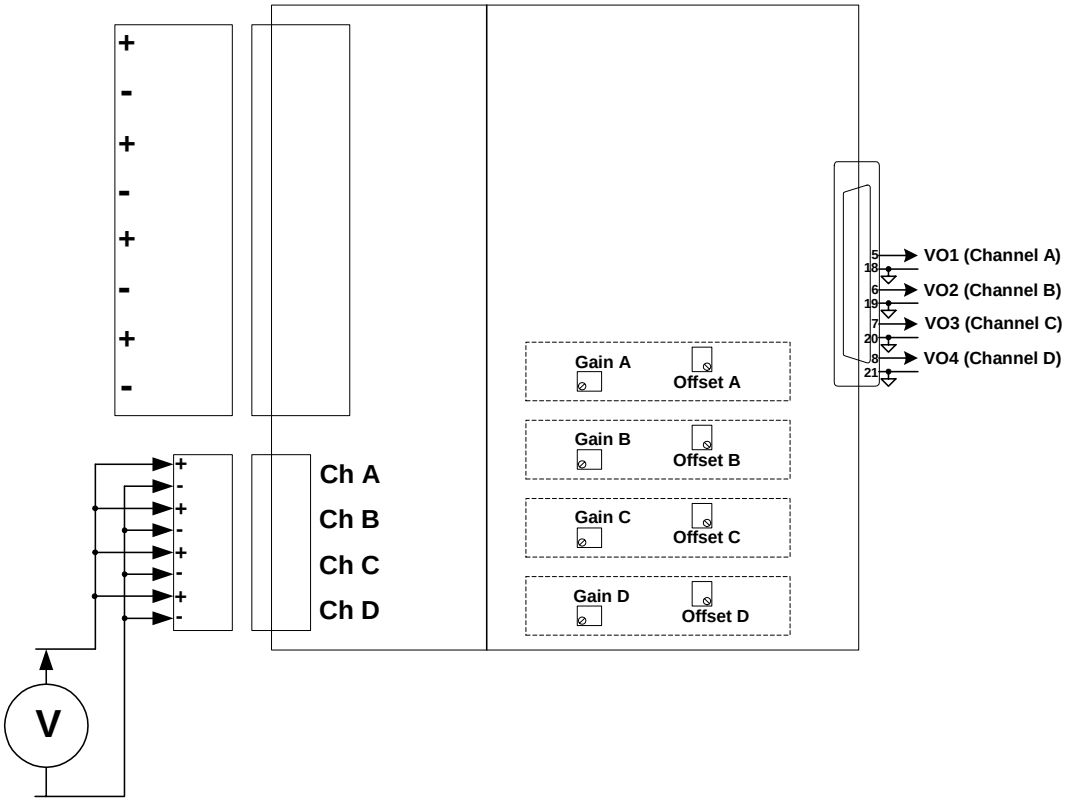
2. CALIBRATION VOLTAGE CHANNEL PROCEDURE:

1.Select the proper range of operation (50v, 100v, 200v, 400v, 600v) with the appropriate jumper for each channel

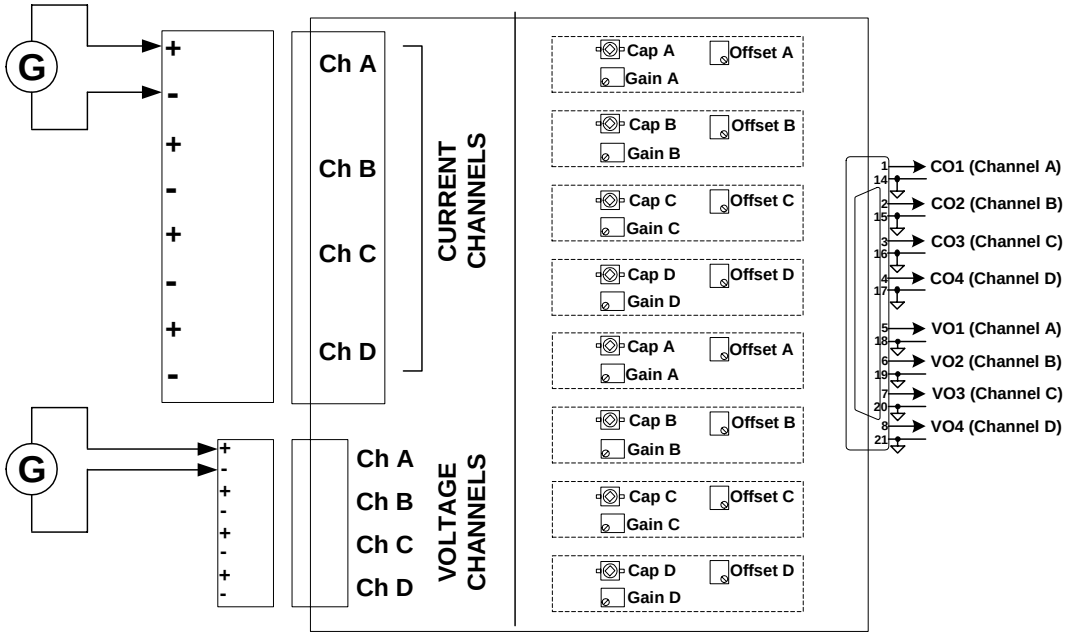
2. Put V to zero by shorting the inputs. Measure at Vox and cancel out the Offset Voltage with the appropriate potentiometers Offset A, Offset B, Offset C, Offset D

3. Put V to a known voltage between 0 and the maximum of the range. Measure at VOx and adjust the Gain with the appropriate potentiometers Gain A, Gain B, Gain C, Gain D

4. If the channels don't have the same range of operation, they must be calibrated individually at the step 3



APPENDIX G. STEP-RESPONSE ADJUSTMENT



CALIBRATION FOR OPTIMAL STEP-RESPONSE:

1.Select the proper SENSOR (5A, 15A, 25A, 50A) with the appropriate jumper for each channel or select the proper range of operation (50v, 100v, 200v, 400v, 600v) with the appropriate jumper for each channel

2. Put a Function Generator G at the corresponding channel inputs.

3. Adjust the corresponding variable capacitor Cap X to get the best step response at the Outputs COx and VOx.